

AMENDED CLAIMS

- 1 1. (currently amended) A method of obtaining nuclear magnetic resonance signals from
2 a fluid obtained from an earth formation, comprising:
3 (a) conveying said fluid into a nuclear magnetic resonance (NMR) sensor in a
4 borehole in said earth formation;
5 (b) enhancing a polarization of a nuclear spin of a nucleus occurring in said
6 fluid; and
7 ~~(d)~~ (c) using said NMR sensor for obtaining NMR signals from said fluid.
8
- 1 2. (previously presented) The method of claim 1 wherein enhancing said polarization of
2 said nuclear spin is based at least in part on the Overhauser effect (OE).
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- 1 3. (previously presented) The method of claim 1 wherein enhancing said polarization of
2 said nuclear spin is based at least in part on the Nuclear Overhauser Effect
3 (NOE).
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- 1 4. (previously presented) The method of claim 1 wherein enhancing said polarization of
2 said nuclear spin is based at least in part on optical pumping.
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- 1 5. (previously presented) The method of claim 1 wherein enhancing said polarization of
2 said nuclear spin is based at least in part on a Spin Induced Nuclear Overhauser

3 Effect (SPINOE).

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1 6. (previously presented) The method of claim 1 wherein enhancing said nuclear spin
2 polarization further comprises:

- 3 (i) introducing a polarizing agent into said fluid; and
4 (ii) polarizing a spin of said polarizing agent, and
5 (iii) transferring a polarization of said polarized agent to said nuclear spin.
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1 7. (previously presented) The method of claim 1, further comprising conveying said sensor
2 downhole on a wireline device.
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1 8. (previously presented) The method of claim 1, further comprising conveying said sensor
2 downhole on a measurement-while-drilling tool.
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1 9. (previously presented) The method of claim 6, wherein said polarizing agent further
2 comprises a noble gas.
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1 10. (previously presented) The method of claim 9, wherein said polarizing agent further
2 comprises xenon.
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1 11. (previously presented) The method of claim 1, wherein said nucleus occurring in said
2 fluid further comprises a carbon-13 nucleus present in at least one of: i) an

3 aliphatic hydrocarbon , ii) an aromatic hydrocarbon, , iii) a connate formation
4 fluid, and, (iv) a mud filtrate.

1 12. (previously presented)The method of claim 6, wherein said polarizing said spin of
2 said polarizing agent further comprises a spin exchange with an intermediate
3 material.

1 13. (previously presented) The method of claim 12 wherein said intermediate material
2 comprises rubidium.

1 14. (previously presented)The method of claim 12 further comprising irradiating said
2 intermediate material with a laser to move electrons of said intermediate material
3 to a higher quantum state

1 15. (previously presented) The method of claim 1, wherein obtaining said nuclear
2 magnetic resonance signal
3 further comprises:
4 i) conveying said fluid within a chamber of said sensor;
5 ii) providing a substantially homogeneous static magnetic field in said
6 chamber;
7 iii) applying a radio frequency pulse sequence to said fluid with at least one
8 transmitter; and

9 iv) obtaining NMR signals from said fluid in response to said radio frequency
10 pulse sequence at at least one receiver antenna.

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1 16. (previously presented) The method of claim 1 wherein obtaining said NMR signals
2 further comprises obtaining spin echo signals.

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1 17. (previously presented) The method of claim 16 further comprising:

2 (i) summing amplitudes of said spin echo measurements;
3 (ii) spectrally analyzing said summed amplitudes;
4 (iii) determining whether aromatic hydrocarbons are present in said fluid
5 sample by measuring an amplitude of said spectrally analyzed summed
6 amplitudes at about 130 parts per million shift from a ^{13}C resonant
7 frequency and determining whether aliphatic hydrocarbons are present in
8 said fluid sample by measuring an amplitude of said spectrally analyzed
9 summed amplitudes at about 30 parts per million frequency shift from said
10 ^{13}C resonant frequency.

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1 18. (previously presented) The method of claim 1 wherein said NMR signals comprise a
2 free induction decay.

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1 19. (previously presented) The method of claim 1 wherein said NMR signals are CW
2 NMR signals to obtain frequency spectra from which chemical shift information is

3 obtained to analyze the chemical composition of the sample under test.

4
1 20. (previously presented) The method of claim 18 where the free induction decay is
2 transformed into a frequency spectrum for analyzing chemical composition from the
3 chemical shift information.

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1 21. (previously presented) The method of claim 1 wherein said NMR signals are
2 associated with a nuclear spin of ^{13}C .

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1 22. (previously presented) The method of claim 15 wherein said NMR signals are
2 associated with a nuclear spin of ^{13}C .

3
1 23. (previously presented) The method of claim 22 wherein providing said substantially
2 homogeneous static magnetic field further comprises using additional NMR
3 signals associated with ^1H .

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1 24. (previously presented) The method of claim 15 wherein providing said substantially
2 homogeneous static magnetic field further comprises using additional NMR
3 signals associated with ^1H .

4
1 25. (previously presented) The method of claim 2 further comprising radiating RF into an
2 ESR-active agent at an ESR frequency of said agent and thereby enhancing the

3 spin polarization of atomic nuclei.

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1 26. (previously presented) The method of claim 3 further comprising changing a nuclear
2 spin polarization of carbon-13 nuclei in said fluid by radiating RF at a NMR
3 frequency of hydrogen nuclei.

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1 27 – 41. Withdrawn

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1 42. (previously presented) An apparatus for use in a borehole in an earth formation for
2 obtaining nuclear magnetic resonance signals from a fluid obtained from said
3 formation, comprising:

4 (a) a nuclear magnetic resonance sensor;

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6 (e)(b) a device for enhancing a polarization of a nuclear spin of a nucleus
7 occurring in said fluid; and

8 (d)(c) a processor for analyzing NMR signals obtained by said NMR sensor from
9 said fluid.

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1 43. (previously presented) The apparatus of claim 42 wherein said device for enhancing
2 said polarization of said nuclear spin uses the Overhauser effect (OE).

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1 44. (previously presented) The apparatus of claim 42 wherein said device for enhancing

2 said polarization of said nuclear spin uses the Nuclear Overhauser Effect (NOE).

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1 45. (previously presented) The apparatus of claim 42 wherein said device for enhancing
2 said polarization of said nuclear spin uses optical pumping.

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1 46. (previously presented) The apparatus of claim 42 wherein said device for enhancing
2 said polarization of said nuclear spin uses a Spin Induced Nuclear Overhauser
3 Effect (SPINOE).

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1 47. (previously presented) The apparatus of claim 42 wherein said device for enhancing
2 said nuclear spin further comprises:

3 (i) an arrangement for introducing a polarizing agent into said fluid; and

4 (ii) an arrangement for polarizing a spin of said polarizing agent,

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1 48. (previously presented) The apparatus of claim 47, wherein said polarizing agent
2 further comprises a noble gas

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1 49. (previously presented) The apparatus of claim 48, wherein said polarizing agent
2 further comprises xenon.

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1 50. (previously presented) The apparatus of claim 42, wherein said nucleus occurring in
2 said fluid further comprises a carbon-13 nucleus present in at least one of: i) an

3 aliphatic hydrocarbon , ii) an aromatic hydrocarbon, , iii) a connate formation
4 fluid, and, (iv) a mud filtrate.
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1 51. (previously presented) The apparatus of claim 47, wherein said polarizing said spin
2 of said polarizing agent further comprises a spin exchange with an intermediate
3 material.
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1 52. (previously presented) The apparatus of claim 51 wherein said intermediate material
2 comprises rubidium.
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1 53. (previously presented) The apparatus of claim 51 further comprising a laser to move
2 electrons from the S to the P quantum state of said intermediate material.
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1 54. (previously presented) The apparatus of claim 42, further comprising:

- 2 i) a fluid chamber;
3 ii) a magnet arrangement for providing a substantially homogeneous static
4 magnetic field in said chamber;
5 iii) a transmitter for applying a radio frequency magnetic field to said fluid;
6 iv) a receiver for obtaining NMR signals from said fluid in response to said
7 radio frequency magnetic field.
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1 55. (previously presented) The apparatus of claim 42 wherein said NMR signals further

2 comprise obtaining spin echo signals.

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1 56. (previously presented) The apparatus of claim 55 further comprising:

2 a processor for:

3 (i) summing amplitudes of said spin echo measurements;

4 (ii) spectrally analyzing said summed amplitudes; and

5 (iii) determining whether aromatic hydrocarbons are present in said fluid

6 sample by measuring an amplitude of said spectrally analyzed summed

7 amplitudes at a first frequency shift from a ^{13}C resonant frequency and

8 determining whether aliphatic hydrocarbons are present in said fluid

9 sample by measuring an amplitude of said spectrally analyzed summed

10 amplitudes at a second frequency shift from said ^{13}C resonant frequency.

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1 57. (previously presented) The apparatus of claim 42 wherein said NMR signals comprise

2 a free induction decay.

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1 58. (previously presented) The apparatus of claim 57 where said processor transforms the

2 free induction decay into a frequency spectrum for analyzing chemical

3 composition from the chemical shift information.

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1 59. (previously presented) The apparatus of claim 42 where said NMR signals comprise a

2 CW frequency spectrum for analyzing chemical composition from the chemical
3 shift information.

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5 60. (previously presented) The apparatus of claim 42 wherein said NMR signals are
2 associated with a nuclear spin of ^{13}C .

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1 61. (previously presented) The apparatus of claim 53 wherein said NMR signals are
2 associated with a nuclear spin of ^{13}C .

3
1 62. (previously presented) The apparatus of claim 43 wherein said NMR sensor includes
2 a transmitter that applies an RF magnetic field to said fluid at an electron spin
3 resonance (ESR) frequency of an ESR-active agent.

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1 63. (previously presented) The apparatus of claim 44 wherein said NMR sensor includes a
2 transmitter that applies an RF magnetic field to said fluid at nuclear resonance
3 frequency of hydrogen nuclei in said fluid.

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1 64 – 75 Withdrawn

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1 76. (previously presented) A system for obtaining nuclear magnetic resonance signals
2 from a fluid obtained from an earth formation, comprising:

3 (a) a logging tool including a nuclear magnetic resonance (NMR) sensor;

- 4 (b) a conveyance device for conveying said fluid into a chamber of said
5 (NMR) sensor;
- 6 (c) an arrangement for enhancing a polarization of a nuclear spin of a nucleus
7 occurring in said fluid;
- 8 (d) a processor for determining from signals obtained by said NMR sensor a
9 property of said fluid; and
- 10 (e) a conveyance device for conveying said logging tool into said earth
11 formation.
12

1 77. (previously presented) The system of claim 76 wherein said conveyance device in (c)
2 is selected from the group consisting of (i) a wireline, and, (ii) a drilling tubular,
3 and, (iii) coiled tubing.
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1 78. (previously presented) The system of claim 76 wherein said arrangement in (c) uses at
2 least one of (i) the Overhauser Effect (OE), (ii) the Nuclear Overhauser Effect
3 (NOE), (iii) optical pumping or (iv) Spin Polarization Induced Nuclear
4 Overhauser Effect (SPINOE).
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1 79. (previously presented) The system of claim 76 wherein said arrangement in (c) uses
2 at least one of (i) a noble gas, (ii) xenon, (iii) an alkaline metal, and, (iv)
3 rubidium.
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- 1 80. (previously presented) The system of claim 76 further comprising a laser for optical
2 pumping of one of (i) a noble gas, and, (ii) xenon.
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4 81-86. Withdrawn